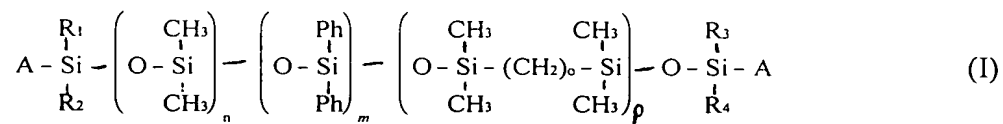


be present. The carbosilane repeat units generally comprise about 2% to 5% by weight of the copolymer.

The copolymers of the present invention also include siloxane repeat units. The siloxane repeat units have up to two carbon groups attached to each silicon atom in one embodiment. These carbon groups may be methyl or phenyl groups. In particular, suitable siloxane repeat units include, but are not limited to, dimethylsiloxane, methylphenylsiloxane, and diphenylsiloxane. Generally, about 10 to 500 dimethylsiloxane repeat units and about 5 to 500 diphenylsiloxane repeat units are present in a chain of the copolymer. The dimethylsiloxane and diphenylsiloxane repeat units generally comprise about 50% to 98% by weight of the copolymer.

In one embodiment, the copoly(carbosilane and siloxane) is a random copolymer having the structure (I):



wherein A is an alkynyl; R₁, R₂, R₃, and R₄ are each a hydrocarbon group; Ph is a phenyl; n is an integer from 10 to 500; m is an integer from 5 to 100; o is an integer from 2 to 12; and p is an integer from 2 to 50.

Suitable terminal alkynyl groups (A) include, but are not limited to, vinyl, allyl, vinylphenyl, allylphenyl, vinylbenzyl and allylbenzyl. The suitable hydrocarbon groups for R₁, R₂, R₃, and R₄ include but are not limited to allyl or aryl groups, such as ethyl, methyl, propyl, butyl and phenyl.

The elastomer may include a platinum catalyst, such as a platinum divinyl complex having 2-3% platinum in xylene, that is added to catalyze the curing of the elastomer, as is well known in the art. Additionally, the elastomer may include a crosslinking agent. Suitable crosslinking agents include organohydrosilanes having multiple hydride groups or containing multiple hydride group polymers. In one embodiment, a hydrodimethyl-terminated silicone is used as the crosslinking agent.

A filler may also be included in the elastomer to reinforce the mechanical properties of the crosslinked elastomer. In one embodiment, the filler is hexamethyldisilazane-treated silica and silicone resin material. The filler may be added in amount of about 8-25 parts filler to 75-92 parts copolymer.

5 The elastomers of the present invention may also include an ultraviolet (UV) light absorbing compound, such as allyl or methallyl functionalized benzotriazoles or benzophenones, for protection against excessive UV radiation. The UV absorbing component may be pre-linked to the crosslinking agent or mixed in separately with the copoly(carbosilane and siloxane).

10 The copolymer having carbosilane and siloxane repeat units may be prepared, for example, by the reaction of octamethylcyclotetrasiloxane and octaphenylcyclotetrasiloxane with vinyl-terminated oligo(carbosilane and siloxane) in the presence of an N-catalyst, such as tetramethylammonium hydroxide or tetraethylammonium hydroxide, at high temperature. The vinyl-terminated oligo(carbosilane and siloxane) may have a molecular weight of about
15 400 to 4000 and from 2 to 50 repeat units of carbosilane. The viscosity of the base copolymer used in the preparation of the final elastomer can range from about 500 cps to 50,000 cps, and preferably 2000 cps to 10000 cps. The base copolymer may then be cured to form the elastomer of the present invention by methods well known in the art.

20 The resulting elastomers are soft, biocompatible and optically clear. The elastomers have a durometer Shore A hardness of at least 15. Further, they have an elongation of at least 100 percent, and a tensile strength of at least about 100 psi, and preferably about 180 to 260 psi. The elastomers of the present invention have a high refractive index, between about 1.43 to 1.55 (at 20° C) in one embodiment, and more particularly at least about 1.46 in another embodiment.

25 The elastomers are particularly useful in the fabrication of ophthalmic lenses and other implantable ocular devices, including intraocular lenses and intraocular contact lenses. The elastomers may be advantageously used for the lens body of the ophthalmic lens, or more particularly the optic of an intraocular lens. The elastomers are soft, biocompatible, and optically clear and have a high refractive index and high strength. They are capable of being
30 deformed for insertion through a small incision in the cornea without breakage and have excellent folding recoverability. The elastomers are also photostable.

The ophthalmic lens bodies may be molded at temperatures of 120°C to 200°C; preferably the molding temperature is in the range of 145°C to 160°C. In yet another embodiment, the lens mold may be shaped so as to produce a lens having suitable curves and geometry such that the molded lens requires little or no additional forming to provide a finished lens.

FIG. 1A depicts an embodiment of an intraocular lens 10 of the present invention. The intraocular lens 10 has an optic 12 formed from an elastomer of the present invention and flexible haptics 14 for positioning the intraocular lens 10 in the eye. The intraocular lens 10 may have one or more haptics, although in this embodiment, two haptics 14 are shown. Also, in this embodiment, the intraocular lens 10 is shown as a multi-piece lens wherein the optic 12 and the haptics 14 are formed from different materials and the haptics 14 are attached to the optic 12 by conventional methods. The haptics 14 may be, for example, a filament of PMMA, polyimide, Kynar® or polypropylene formed by extrusion. As one skilled in the art will appreciate, the intraocular lens may alternatively be a one-piece design wherein the optic and haptics are formed from a single piece of the elastomer of the present invention. FIG. 1B depicts a side view of the intraocular lens 10 of FIG. 1A, further showing the optic 12 and haptics 14.

FIG. 2A depicts another embodiment of an intraocular lens of the present invention. In FIG. 2A, a plate-type haptics lens 16 having a lens body 18 is shown. As seen from the illustration in FIG. 3A, the lens body 18 has a generally rectangular shape and includes a central optic zone or optic 20 formed from an elastomer of the present invention and plate-type haptics 22 extending from diametrically opposite edges of the optic 20. FIG. 2B depicts a side-view of the plate-type haptics lens 16 shown in FIG. 2A.

In addition, the elastomers of the present invention can be used to produce other transparent objects requiring a high refractive index and an optically clear, soft material.

The invention will now be further illustrated by the following examples which are intended to be illustrative and non-limiting.

EXAMPLE 1

This example illustrates the preparation of oligo(carbosilane and siloxane) (A) which is used in the preparation of the copoly(carbosilane and siloxane) elastomer. In a 250 ml three-necked round bottom flask, 150 grams of 1,3-divinyldimethyltetramethyldisiloxane and 13 milligrams of platinum catalyst were stirred and heated to 100° C. Over a period of 25 minutes, 25 grams of tetramethyldisiloxane were added dropwise to the flask. The mixture was stirred at 100° C for an additional hour. Excess 1,3-divinyldimethyltetramethyldisiloxane was removed under vacuum conditions until no further low boiling point material remained, leaving behind a yellow, slightly viscous material. GPC analysis showed that this material had an average molecular weight of about 500. ¹H NMR spectra showed that the material was oligo(carbosilane and siloxane).

EXAMPLE 2

A higher molecular weight oligo(carbosilane and siloxane) (B) was prepared from the oligo(carbosilane and siloxane) (A) of Example 1 as follows. In a 250 ml three-necked round bottom flask, 15 grams of tetramethyldisiloxane and 13 milligrams of platinum catalyst were stirred and heated to 80° C. Over a period of 15 minutes, 15 grams of oligo(carbosilane and siloxane) (A) were added dropwise to the flask. The mixture was stirred at 100° C for an additional hour. Excess tetramethyldisiloxane was removed under vacuum conditions until no further low boiling point material remained. The mixture was then cooled to room temperature.

Next, 50 grams of 1,3-divinyldimethyltetramethyldisiloxane and 13 milligrams of catalyst are added to a second 250 ml three-necked round bottom flask and stirred and heated to 100° C. Over a period of 15 minutes, the material from the first flask was added dropwise to the second flask. The mixture was stirred at 100° C for an additional hour. Low boiling point material was removed under high vacuum, leaving behind a yellow, high viscosity oligomer (B). GPC analysis showed that this material had an average molecular weight of about 1000. ¹H NMR spectra showed that the material was oligo(carbosilane and siloxane).

EXAMPLE 3

Examples 3 through 7 illustrate the preparation of copoly(carbosilane and siloxane) from oligo(carbosilane and siloxane) A and B in accordance with principles of the present invention.

5 In a 500 ml three-necked round bottom flask, 44.6 grams of octaphenylcyclotetrasiloxane, 93.5 grams of octamethylcyclotetrasiloxane, 5.1 grams of vinyl dimethyl siloxy-terminated oligo(carbosilane and siloxane) (B) and 0.14 grams of N-catalyst were mixed. The mixture was stirred and heated to 100° to 120° C for 2 to 4 hours until the octaphenylcyclotetrasiloxane had completely dissolved and the mixture
10 turned into a viscous brown solution. The mixture was then cooled to room temperature and 150 ml of methylene chloride was added and stirred into the mixture. Next, 75 ml of methyl alcohol and 100 ml of distilled water were added and the mixture was stirred again at room temperature for 15 minutes. The organic layer was separated and another 75 ml of methyl alcohol and 100 ml of distilled water were added to the separated organic layer.
15 The organic layer was separated again and dried over magnesium sulfate. After filtering, the solvent was then removed under vacuum. The resulting material was a colorless copoly(carbosilane and siloxane) with a viscosity of 4400 cps and a refractive index of 1.465.

EXAMPLE 4

20 In a 500 ml three-necked round bottom flask, 41.0 grams of octaphenylcyclotetrasiloxane, 99.0 grams of octamethylcyclotetrasiloxane, 6.1 grams of vinyl dimethyl siloxy-terminated oligo(carbosilane and siloxane) (B) and 0.14 grams of N-catalyst were mixed. The mixture was stirred and heated to 100° to 120° C for 2 to 4 hours until the octaphenylcyclotetrasiloxane had completely dissolved and the mixture
25 turned into a viscous brown solution. The mixture was then cooled to room temperature and 150 ml of methylene chloride was added and stirred into the mixture. Next, 75 ml of methyl alcohol and 100 ml of distilled water were added and the mixture was stirred again at room temperature for 15 minutes. The organic layer was separated and another 75 ml of methyl alcohol and 100 ml of distilled water were added to the separated organic layer.
30 The organic layer was separated again and dried over magnesium sulfate. After filtering,

the solvent was then removed under vacuum. The resulting material was a colorless copoly(carbosilane and siloxane) with a viscosity of 4200 cps and a refractive index of 1.462.

EXAMPLE 5

5 In a 500 ml three-necked round bottom flask, 44.6 grams of octaphenylcyclotetrasiloxane, 93.5 grams of octamethylcyclotetrasiloxane, 3.1 grams of vinyltrimethylsiloxy-terminated oligo(carbosilane and siloxane) (A) and 0.14 grams of N-catalyst were mixed. The mixture was stirred and heated to 100° to 120° C for 2 to 4
10 hours until the octaphenylcyclotetrasiloxane had completely dissolved and the mixture turned into a viscous brown solution. The mixture was then cooled to room temperature and 150 ml of methylene chloride was added and stirred into the mixture. Next, 75 ml of methyl alcohol and 100 ml of distilled water were added and the mixture was stirred again at room temperature for 15 minutes. The organic layer was separated and another 75 ml of methyl alcohol and 100 ml of distilled water were added to the separated organic layer.
15 The organic layer was separated again and dried over magnesium sulfate. After filtering, the solvent was then removed under vacuum. The resulting material was a colorless copoly(carbosilane and siloxane) with a viscosity of 4600 cps and a refractive index of 1.466.

EXAMPLE 6

20 In a 500 ml three-necked round bottom flask, 40.0 grams of octaphenylcyclotetrasiloxane, 93.5 grams of octamethylcyclotetrasiloxane, 3.1 grams of vinyltrimethylsiloxy-terminated oligo(carbosilane and siloxane) (A) and 0.14 grams of N-catalyst were mixed. The mixture was stirred and heated to 100° to 120° C for 2 to 4
25 hours until the octaphenylcyclotetrasiloxane had completely dissolved and the mixture turned into a viscous brown solution. The mixture was then cooled to room temperature and 150 ml of methylene chloride was added and stirred into the mixture. Next, 75 ml of methyl alcohol and 100 ml of distilled water were added and the mixture was stirred again at room temperature for 15 minutes. The organic layer was separated and another 75 ml of methyl alcohol and 100 ml of distilled water were added to the separated organic layer.

The organic layer was separated again and dried over magnesium sulfate. After filtering, the solvent was then removed under vacuum. The resulting material was a colorless copoly(carbosilane and siloxane) with a viscosity of 4150 cps and a refractive index of 1.462.

EXAMPLE 7

In a 500 ml three-necked round bottom flask, 41.0 grams of octaphenylcyclotetrasiloxane, 99.0 grams of octamethylcyclotetrasiloxane, 3.6 grams of vinyl dimethyl siloxy-terminated oligo(carbosilane and siloxane) (A) and 0.17 grams of N-catalyst were mixed. The mixture was stirred and heated to 100° to 120° C for 2 to 4 hours until the octaphenylcyclotetrasiloxane had completely dissolved and the mixture turned into a viscous brown solution. The mixture was then cooled to room temperature and 150 ml of methylene chloride was added and stirred into the mixture. Next, 75 ml of methyl alcohol and 100 ml of distilled water were added and the mixture was stirred again at room temperature for 15 minutes. The organic layer was separated and another 75 ml of methyl alcohol and 100 ml of distilled water were added to the separated organic layer. The organic layer was separated again and dried over magnesium sulfate. After filtering, the solvent was then removed under vacuum. The resulting material was a colorless copoly(carbosilane and siloxane) with a viscosity of 8650 cps and a refractive index of 1.461.

TABLE 1 summarizes the compositions and properties of the copolymers of Examples 3 through 7.

TABLE 1					
Example #:	3	4	5	6	7
Composition (g)					
D ₄ Ph	44.6	41.0	44.6	40.0	41.0
D ₄	93.5	99.0	93.5	93.5	99.0
OCS	5.1(B)	6.1(B)	3.1(A)	3.1(A)	3.6(A)
N-catalyst	0.14	0.14	0.14	0.14	0.17
Properties					
Viscosity (cps)	4400	4200	4600	4150	8650
Refractive Index	1.465	1.462	1.466	1.462	1.46

D₄Ph-octaphenylcyclotetrasiloxane
D₄-octamethylcyclotetrasiloxane
OCS-oligo(carbosilane and siloxane)

EXAMPLE 8

5 The remaining examples illustrate the preparation of various embodiments of the elastomer of the present invention from the exemplary copolymers prepared in Examples 3 through 7.

10 In a 500 ml glass flask, 80.0 grams of the copolymer of Example 3 was mixed with 24.0 grams of hexamethyldisilazane-treated silica. The mixture was mechanically stirred and heated to 120° C for 2 to 5 hours. Then, the mixture was cooled to room temperature and 4.0 grams of hydrodimethyl-terminated silicone crosslinking agent, 1.0 grams of tris(vinyl dimethylsiloxysilane), 104.0 milligrams of tetravinyltetramethyl-
15 cyclotetrasiloxane, and 26.0 milligrams of platinum divinyl complex (2-3% platinum concentration in xylene) were added and mixed until the mixture turned clear. The mixture was degassed for about 20 to 50 minutes to remove all air bubbles in the mixture. The mixture was then transferred into a sheet casting fixture and cast at 150° C for 1.5 hours. After cooling to room temperature, the sheet was removed and cut into the desired shape. The final product had an elongation of 195% and a tensile strength of 260 psi.

EXAMPLE 9

20 In a 500 ml glass flask, 80.0 grams of the copolymer of Example 4 was mixed with 16.0 grams of hexamethyldisilazane-treated silica. The mixture was stirred and heated to 120° C for 2 to 5 hours. Then, the mixture was cooled to room temperature and 2.0 gram of hydrodimethyl-terminated silicone crosslinking agent, 104.0 milligrams of tetravinyltetramethylcyclotetrasiloxane, and 13.0 milligrams of platinum divinyl complex
25 (2-3% platinum concentration in xylene) were added and mixed until the mixture turned clear. The mixture was degassed for about 20 to 50 minutes to remove all air bubbles in the mixture. The mixture was then transferred into a sheet casting fixture and cast at 150° C for 1.5 hours. After cooling to room temperature, the sheet was removed and cut into the desired shape. The final product had an elongation of 150 % and a tensile strength of 210
30 psi.

EXAMPLE 10

In a 500 ml glass flask, 80.0 grams of the copolymer of Example 5 was mixed with 22.5 grams of hexamethyldisilazane-treated silica. The mixture was stirred and heated to 120° C for 2 to 5 hours. Then, the mixture was cooled to room temperature and 4.0 grams of hydrodimethyl-terminated silicone crosslinking agent, 1.0 grams of tris(vinyl dimethylsiloxysilane), 104.0 milligrams of tetravinyltetramethylcyclotetrasiloxane, and 26.0 milligrams of platinum divinyl complex (2-3% platinum concentration in xylene) were added and mixed until the mixture turned clear. The mixture was degassed for about 20 to 50 minutes to remove all air bubbles in the mixture. The mixture was then transferred into a sheet casting fixture and cast at 150° C for 1.5 hours. After cooling to room temperature, the sheet was removed and cut into the desired shape. The final product had an elongation of 200% and a tensile strength of 210 psi.

EXAMPLE 11

In a 500 ml glass flask, 80.0 grams of the copolymer of Example 6 was mixed with 24.0 grams of hexamethyldisilazane-treated silica. The mixture was stirred and heated to 120° C for 2 to 5 hours. Then, the mixture was cooled to room temperature and 4.0 grams of hydrodimethyl-terminated silicone crosslinking agent, 104.0 milligrams of tetravinyltetramethylcyclotetrasiloxane, and 26.0 milligrams of platinum divinyl complex (2-3% platinum concentration in xylene) were added and mixed until the mixture turned clear. The mixture was degassed for about 20 to 50 minutes to remove all air bubbles in the mixture. The mixture was then transferred into a sheet casting fixture and cast at 150°C for 1.5 hours. After cooling to room temperature, the sheet was removed and cut into the desired shape. The final product had an elongation of 200% and a tensile strength of 230 psi.

EXAMPLE 12

In a 500 ml glass flask, 80.0 grams of the copolymer of Example 7 was mixed with 8.5 grams of hexamethyldisilazane-treated silica. The mixture was stirred and heated to 120° C for 2 to 5 hours. Then, the mixture was cooled to room temperature and 2.4 grams of hydrodimethyl-terminated silicone crosslinking agent, 104.0 milligrams of

tetravinyltetramethylcyclotetrasiloxane, and 26.0 milligrams of platinum divinyl complex (2-3% platinum concentration in xylene) were added and mixed until the mixture turned clear. The mixture was degassed for about 20 to 50 minutes to remove all air bubbles in the mixture. The mixture was then transferred into a sheet casting fixture and cast at 150° C for 1.5 hours. After cooling to room temperature, the sheet was removed and cut into the desired shape. The final product had an elongation of 180% and a tensile strength of 180 psi.

Table 2 summarizes the elastomer compositions and properties of Examples 8 through 12.

TABLE 2					
Example #:	8	9	10	11	12
Composition (g)					
CPCS	80.0	80.0	80.0	80.0	80.0
Silica	24.0	16.0	22.5	22.5	8.5
Crosslinker	4.0	2.0	4.0	2.4	2.4
TVDMS	1.0		1.0		
TVTMCTS	0.104	0.104	0.104	0.104	0.104
Platinum Catalyst	0.026	0.026	0.026	0.026	0.026
Properties					
Elongation (%)	195	150	200	200	180
Tensile Strength (psi)	260	210	210	230	280
CPCS-copoly(carbosilane and siloxane)					
Silica-hexamethyldisilazane treated silica					
Crosslinker-hydrodimethylsiloxane					
TVDMS-tris(vinyldimethylsiloxysilane)					
TVTMCTS-tetravinyltetramethylcyclotetrasiloxane					

While several specific embodiments of the invention have been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited, except as by the appended claims.